Boat-Related Carbon Monoxide (CO) Poisonings on U.S. Waters

At the request of the U.S. Coast Guard, the interagency team investigating CO poisonings at Lake Powell compiled the following listing of CO poisonings from across the country. Case reports forwarded to and otherwise discovered by the team are included in the listing. It should not be viewed as a complete list of past poisonings and will continue to be updated with new information.

The listed case reports are grouped into the following categories: I Outdoor CO Poisonings on Houseboats; II Outdoor CO Poisonings on Cabin Cruisers and Ski Boats; III Indoor CO Poisonings on Houseboats; IV Indoor CO Poisonings on Cabin Cruisers or Boats with Canopies; and V CO Poisonings on Unspecified Boats. Each listing includes the name of the body of water (if known), a brief summary of the circumstances of the poisoning, and the source of the information.

I. Outdoor CO Poisonings on Houseboats - U.S. Waters

■ *19 CO-Related Fatalities in this Category* ‣ *45 Non-Fatal CO Poisonings in this Category*

Lake Powell, Arizona and Utah – for more information about the Lake Powell poisonings, please see other publications listed on the website.

■■■■■■■■ Since 1994, there have been eight fatal outdoor poisonings on or near houseboats on Lake Powell. All eight fatalities have occurred on privately owned boats, and all have occurred on boats with a stern deck that extends several feet beyond the transom, a lower swim platform, and a rear-directed generator exhaust terminus. All but two of the deaths were associated with exposure to generator exhaust. One death was attributed to both generator and propulsion engine exhaust. The remaining death was associated with propulsion engine exhaust only. All but two of these deaths were witnessed, and the witnessed deaths all occurred within seconds or minutes of exposure. (Source: Interagency Investigation Data)

‣ Since 1990, there have been 31 non-fatal outdoor poisonings on or near houseboats on Lake Powell. Twenty-two of these poisonings were associated with exposure to generator exhaust only; 2 were associated with propulsion engine exhaust only; 1 was associated with exhaust from both types of engines; and the remaining 5 were associated with the operation of an engine that was not clearly described in the record. Eighteen of these poisonings resulted in loss of consciousness, and 13 of these people lost consciousness while in the water (thus were near-drownings). (Source: Review of NPS EMS Records, Glen Canyon National Recreation Area)

Center Hill Lake, Tennessee

■■ In May 1997, a father dove under the stern deck of his houseboat to repair a mechanical problem. According to the Tennessee Wildlife Resources Agency, he entered an airspace beneath the stern deck into which the exhaust of the operating onboard generator was directed. Because the father did not surface, his son dove under the boat to find him. Both men died of CO poisoning while in that cavity. (Sources: Arizona Republic, November 29, 2000; and Tennessee Wildlife Resources Agency investigative records) **Rear-directed generator exhaust terminus**

Tims Ford Lake, Tennessee

‣ In July 1999, a 7-year-old boy wearing a type III personal floatation device was playing and swimming on and near the swim deck of a 1979 46’ Stardust houseboat when he was overcome by exhaust from the on-board generator. He fell into the lake and was found floating on his back unresponsive and in convulsions. He was rescued by others on the boat. (Source: Tennessee Wildlife Resources Agency Boating Accident Report) **Rear-directed generator exhaust terminus**

■ ‣ A 61-year-old woman wearing a ski belt while cleaning algae from the back of a 1990 Gibson 42’ houseboat died from CO exposure in June 2000. She had been in the water approximately 20 minutes when her husband went outside and saw her floating 30 feet from the boat on her back and unresponsive. He worked for approximately 30 minutes to pull her from the water onto the swim platform. At this point, he began to feel lightheaded. He got back into the boat and deactivated the generator. Because a storm was approaching, and he was afraid that his wife would be blown away, he tied his wife’s body to the swim platform until rescuers arrived. His wife died of CO poisoning, and he was admitted to a hospital intensive care unit for CO poisoning treatment. The wife’s blood CO concentration was 62%. (Sources: Arizona Republic, November 29, 2000; also AP, December 25, 2000; and Tennessee Wildlife Resources Agency Boating Accident Report) **Rear-directed generator exhaust terminus**

Norris Lake, Tennessee

■ In July 1999, a 45-year-old man went into the water to repair the slide on his 77’ 1995 Stardust houseboat. Approximately 5 minutes after he swam under the stern deck of the houseboat, two minors on board went to get help because they did not see the man resurface. His body was recovered from the lake about 3 hours later. Although no autopsy was performed, blood was drawn and analyzed for carboxyhemoglobin (COHb – CO in blood) content, which was 37%. (Source: Tennessee Wildlife Resources Agency Boating Accident Report) **Rear-directed generator exhaust terminus**

Unspecified water body, Tennessee

■ In 1998, a child found floating near the rear of a houseboat that had its generator operating was found to have died because of carbon monoxide exposure. (Source: Tennessee Wildlife Resources Agency Investigative Report) **Unspecified direction of generator exhaust terminus**

Dale Hollow Lake, Tennessee

■ In June 1997, a family rented a houseboat from Hendrick Creek Resort on Dale Hollow Lake. Several children were playing on the slide and around the back of the boat all day while the generator operated to power the air conditioning inside the boat. One of the children (aged 9) reported to her mother three times that day that she felt sick, but her symptoms were attributed to the hot weather and sun. Her mother had also been feeling ill when she sat in a tube tied to the back deck of the houseboat, and attributed her symptoms to the exhaust, but not necessarily to CO. The mother had the child go in a lie down for a few hours, and then let her go back out to swim. In the afternoon, the child swam on the side of the boat where the generator exhausted because that area was shaded from the sun. The exhaust exited the boat very near the area where she swam. Her 7-year-old brother was on the stern deck playing. He was talking to her and she told him that she felt sick. He told her to get out of the water. She was reaching for the ladder, and did not make it. She sank into water that was 8-11 feet deep. The boy reported to his mother that the girl had gone down and didn't come back up. The child's body was found by emergency responders. Although an autopsy was performed, no carboxyhemoglobin analysis was done. (Sources: Personal communication from the child's family; and Tennessee Wildlife Resources Agency Boating Accident Report) **Unspecified direction of generator exhaust terminus**

Silver Glen Springs, Florida

■ In August 1995, a man wearing snorkel gear went into the airspace beneath the extended rear deck of a 1994 Stardust houseboat to check the engine outdrive. The boat's 12.5 kW Kohler generator was activated just before he entered the airspace. The generator exhaust terminus was directed into the airspace. The boat propulsion engines were not operating. Approximately 5 minutes after he entered the airspace, he was observed floating unresponsively face down in the shallow water. He was retrieved from the water and bystanders administered CPR. He was then transported to shore, and Emergency Medical Service was called. He was resuscitated in the hospital emergency department, and but died 17 hours after his exposure. His COHb (carboxyhemoglobin – CO in the blood) measured in the hospital 2 hours after exposure, and after more than an hour on oxygen therapy, was 29.7%. A forensic toxicologist estimated that the man's COHb was greater than 70% when he collapsed. Inspection and testing of the houseboat revealed that operation of the generator caused rapid accumulation of CO in the above-water airspace beneath the deck (the airspace he entered) such that the concentration would reach 4,000 to 10,000 ppm within 2 to 5 minutes after the generator was activated. The cause of death determined by autopsy was cerebral anoxia, due to acute carbon monoxide poisoning with submersion. (Source, Lab Director, Miami-Dade County Medical Examiner Department) **Rear-directed generator exhaust terminus**

Lake of the Ozarks, Missouri

‣ In June 1998, a 4-year-old girl was swimming behind the stern deck of a Gibson houseboat with a group of other children. She wearing a personal flotation device, and was under the direct supervision of adult swimmers. After she swam to the swim platform, holding on to the ladder while her mother applied sunscreen to her face, she swam away. Within moments she was observed floating face up on the water, unconscious and rigid. She was quickly brought into the boat where her mother, a registered nurse, checked her for respirations and pulse. She appeared pale and stiff at that time, was unresponsive with poor respiratory effort. After 2 to 3 minutes of aggressive stimulation, the child began responding with grunts but was described as disoriented and sleepy. While her mother continued rescue efforts, her father called for emergency medical services. Paramedics arrived in 10 to 15 minutes, administered oxygen, and transported the child to the nearest hospital emergency department within 30-45 minutes. Her venous COHb level at the hospital after approximately 1 hour of oxygen therapy was 22.2%. Upon examining the houseboat during their next visit to the lake, the child's parents discovered that the exhaust terminus for the onboard generator that was operating at the time of this poisoning was located at the edge of the swim platform, in the center of the rungs of the ladder that the child was holding onto when the sunsreen was applied. (Multiple sources including the parents and a peer-reviewed publication) **Rear-directed generator exhaust terminus**

Lake of the Ozarks, Missouri (continued)

■ In the summer of 1999, a man died on this lake as he swam behind a houseboat. An autopsy revealed that death came not from drowning, but by asphyxiation from CO. We currently have no further information on this death. (Source: Kansas City Star, 12/14/00, Lee Hill Kavanaugh) **Unspecified direction of generator exhaust terminus**

Lake Havasu, Arizona

■ ■ ▸ ▸ A past general manager of 3 Buoys Houseboat Vacations reported the following information: The company was based in Canada, but had 11 marinas in the US. One of the marinas was on Lake Havasu, where they had 75 boats that were time share/rentals (several owners, but also rented to non-owners). Their boats were 54' long, 14'wide, with generators that exhausted under the rear deck at water level. In 1985, two employees died from CO exposure while sitting on the rear swim platform when the generator operated. The following year, two customers of the same company were poisoned in the same circumstance - sitting on the rear deck platform. (Source: Personal communication, Past Manager of the Houseboat Rental Company) **Rear-directed generator exhaust terminus**

Lake Travis, Texas

▸ A 19-year-old employee of a houseboat rental company was piloting a 66' houseboat (no manufacturer specified) when a buoy cable became entangled in the engine propeller. After deactivating the generator (the exhaust of which was directed to the rear of the boat into the airspace beneath the swim deck) and waiting a few minutes to assess the situation, he decided to go under the aft swim deck of the boat to free the cable. He was aware of the carbon monoxide (CO) danger and made efforts to avoid breathing while under the swim deck. Unable to hold his breath long enough, he was forced to take two breaths while working to free the cable. A coworker arrived on the scene minutes later to find the employee unconscious. The employee was airlifted to the nearest hospital. Doctors later reported that his blood carbon monoxide level was in the lethal range, although no specific details were available from the reporter of this incident. (Source: Personal communication from the rental company manager, Austin TX) **Rear-directed generator exhaust terminus**

▸ ▸ ▸ Upon reading the press coverage of the poisonings at Lake Powell, the manager of a fleet of 9 large rental houseboats phone to say "We've been waiting for this day for years." Between 1995 and 2000, he had personal involvement with four documentable cases of aft swim-deck CO poisonings (including the one above) and indirect knowledge of numerous others. None were fatalities, but two required hyperbaric oxygen treatment. All involved generator exhaust routed under the swim deck at the back of the boat. (Source: Personal communication from the rental company manager, Austin TX) **Rear-directed generator exhaust terminus**

Table Rock Lake, Missouri

▸ ▸ In the summer of 1999, two girls swimming behind a houseboat succumbed to generator exhaust, but were rescued in time. (Source: Kansas City Star, 12/14/00, Lee Hill Kavanaugh). Records related to this incident revealed that the children were aged 8 and 11, and were found unconscious floating behind the Gibson 54' houseboat. One of the girls was not breathing when she was found. The girls had been wearing personal flotation devices swimming behind the boat as the boat owner worked on the front of the boat. The generator (no manufacturer specified) was operating at the time, and the exhaust of the generator "comes out of the boat right under the swim platform where they were swimming." (Source: Missouri Department of Public Safety, Missouri State Water Patrol Accident Investigation Report) **Rear-directed generator exhaust terminus**

Lake Mead, Nevada

‣ In July 1997, a man working to clear a rope from around the propellor on a rented houseboat lost consciousness as a result of exposure to CO in generator exhaust. (Source: Review of NPS EMS records, Lake Mead National Recreation Area) **Unspecified direction of generator exhaust terminus**

‣ In October 1997, an 8-year-old child floating in a small rubber raft on the starboard side of a houseboat was poisoned by CO in houseboat generator exhaust. He was exposed for about 5 minutes when he became dizzy, and fell down when he tried to walk. He was transported to a local hospital for treatment. (Source: Review of NPS EMS records, Lake Mead National Recreation Area) **Unspecified direction of generator exhaust terminus**

‣ In June 1999, a child was playing near a houseboat generator for about 10 minutes when she fell into the water and lost consciousness as a result of CO exposure. (Source: Review of NPS EMS records, Lake Mead National Recreation Area) **Unspecified direction of generator exhaust terminus**

Kerr Lake, North Carolina/Virginia

■ In 1995, a man in his 40's entered the airspace beneath the extended stern deck of a 60' houseboat (manufacturer unknown) to conduct repairs. The home dock of this houseboat was Steel Creek Marina. The on-board generator with a rear-direct exhaust terminus was operating when he entered the airspace. He quickly died of CO poisoning. The local Coast Guard Auxiliary was contacted, and a full investigation was conducted. The reporter of the incident did not know who conducted the investigation (i.e., Coast Guard, law enforcement, State Wildlife, etc.) but did remember that the man's death was directly attributed to the design of the boat. Circumstances of the death were widely known among other boat owners at the marina because of extensive publicity about it at the time, and many were concerned about the potential hazards revealed by this man's death. The man had not been drinking, and alcohol was not listed as a contributing factor. (Source: Report by a private individual whose boat was also docked at Steel Creek Marina) **Rear-directed generator exhaust terminus**

II. Outdoor CO Poisonings on Cabin Cruisers and Ski Boats – U.S. Waters

■ *12 CO-Related Fatalities in this Category* ‣ *19 Non-Fatal CO Poisonings in this Category*

Lake Powell, Arizona and Utah

Since 1990, two people have died from CO poisoning on Lake Powell while being seated in an open boat or occupying the rear platform of the boat. The circumstances of these poisonings are listed below:

■ In July 1995, a 16-year-old girl died while riding in a slowly moving 20.5' Bahmer boat powered by a 454 cubic inch Chevrolet inboard propulsion engine with jet drive. She was sitting in the driver's side transom seat very close to the exhaust ports. The boat was traveling at about 10 miles per hour while towing a personal water craft. The trip from the campsite to the boat dock took about 45 minutes. When the boat reached the wakeless buoys, other passengers noticed that the girl was limp, with her chest arched in the air and her hair trailing behind in the water. She was transported to a nearby hospital emergency department, and then on to a second hospital in Phoenix. She was pronounced dead a day after she was exposed.

■ ‣ ‣ In June 2001, an 18-year-old passenger of a 1993 21' Master Craft ProStar 205 ski boat drowned in Lake Powell as a result of CO poisoning. There were 10 passengers on the boat at the time. At the time of the death, three of the 10 passengers were being pulled behind the boat in an activity referred to as "teak surfing". This activity was described by this and other families as very common and "what wake boarders do when they are not on their board". The operator of the boat reported having been teak surfing on this boat at least 15 times, and his father reported that the activity had been done by others on this boat at least a hundred times. None of the people teak surfing were wearing a personal floatation device (PFD). Shortly after beginning teak surfing (estimated less than 2 minutes), one of the teenagers was unable to maintain her hold on the platform. She was reported as having "jerky arm movements" and difficulty in communicating. She was pulled into the boat by the passengers, where she recovered. Another teen took her position on the platform, and they began teak surfing again. Approximately 1-2 minutes later, one of the three teens began to experience unspecified symptoms. Two of the three teens then pulled themselves up onto the swim platform while the boat continued to move forward. The third surfer, still positioned for teak surfing, lost consciousness and released his hold on the platform. He sank beneath the surface. His body was retrieved from the water three days later. His COHb on autopsy was 57%. Subsequent measured CO concentrations on the platform ranging between 10,000 and 27,000 parts per million (ppm) under similar circumstances were in agreement with exposure estimates calculated to be between 10,000 and 16,000 ppm based on his COHb concentration and estimated time of exposure.

‣ Since 1990, 12 people survived CO poisoning outdoors on pleasure craft (boats other than houseboats) on Lake Powell. Seven of the 12 lost consciousness. All 12 people were poisoned by propulsion engine exhaust. Four of the 12 people were riding in a moving boat (again, no canopy or other type of enclosure was involved in these poisonings). Three of the 12 people were outside in a boat being towed by another boat. The remaining 5 of 12 people poisoned outdoors were in the water when they were poisoned, as described below:

Two were poisoned during the teak surfing event described above.

One poisoning occurred while the person was "holding onto a swim deck and handle while being towed." This person lost consciousness within 5 minutes of beginning this activity, was recovered from the water and revived.

Circumstances of the second incident were described as follows: "swimming behind a boat for 10-15 minutes." This person lost consciousness, recovered, and had a carboxyhemoglobin (COHb) measurement of 32%.

The circumstances of the remaining incident were described as: "behind a boat with motors running for 2 hours." This person lost consciousness but lived, and had a COHb of 18%.

(Source: Review of NPS EMS Records, Glen Canyon National Recreation Area)

Lake Sylvan, Ohio

■ In August 2000, an 11-year-old girl was riding on the swim platform of a 21' inboard Malibu ski boat with two friends who were near her age. The boat was moving slowly (operating under 10 miles per hour) while the children lay on their stomachs on platform with their legs dangling in the water. The weather was calm and clear. The girl began to lose consciousness, falling from the boat, grabbing the ankle of the child next to her as she went. The third child on the platform dove into the water to try and save the other two, as did another boat passenger. The 11-year-old girl disappeared from view and drowned. Her autopsy carbon monoxide blood concentration (carboxyhemoglobin – COHb) was 50%. (Source: Ohio Division of Water Craft records) **Propulsion engine exhaust**

Ocoee Lake, Tennessee

■ In June 1995, three girls were being towed at idle speed behind a 19' Malibu ski boat powered by a 1993 Mercruiser 5.7 liter engine. They were holding onto the swim board attached to the boat transom. One of the girls was wearing a n adult-sized extra-large Type III personal flotation device (PFD) with the top of three buckles unfastened. She comment to the others that she did not feel well. Just after making that statement, she lost consciousness, let go of the deck, slipped out of the PFD, drifted about two feet, and sank. Her body was recovered in 95' feet of water two days later. Her COHb concentration was 62%. (Source: Tennessee Boating Accident Investigation Record) **Propulsion engine exhaust**

Bartlett Lake, Arizona

■ In spring, 1998 a family was enjoying an afternoon of boating, skiing, swimming, and wakeboarding over a 2-hour, mid-afternoon period. The victim and 3 children of similar age were being slowly pulled through the water while holding onto the wooden swim platform attached to the rear transom of the boat. The boat was a 1992 MasterCraft Ski-ProStar 205, with a fully exposed propeller, centered at the rear underside of the water craft. At one point, the victim was the only person being pulled through the water, with the three mates sitting immediately nearby on the platform, and two adults located in the front of the boat. Signs of trouble occurred without warning (within a time span of a few seconds). When the victim's swim trunks started to slip off, he uttered an exclamation, and released one hand to grab his clothing. Water gushed up into his face. He then turned around as if to say something. His eyes rolled back, and he released the platform with his other hand as well. He then disappeared underwater. He was not wearing a personal floatation device. Divers recovered his body the following day. The medical examiner's report showed 48% COHb. Cause of death was determined as "drowning, due to carbon monoxide incapacitation due to inhalation of exhaust." The certificate of death listed drowning (but not CO poisoning) as the cause of death. Investigators' reports did not indicate malfunction of the boat or motor, nor did any witness describe the odor of fumes or exhaust. No other passenger on the boat described becoming ill. (Source: Arizona Health Department; Maricopa county Sheriff's Department investigative records) **Propulsion engine exhaust**

Unspecified water body, California

‣ ‣ In 1997, the operator of an open motorboat was cruising at approximately 5 miles per hour with his two children sitting on the swim step. The children were overcome by exhaust. Both were taken to the hospital for treatment – one needed oxygen therapy. (Source: US Coast Guard Database) **Propulsion engine exhaust**

Discovery Bay, California

■ In June 2000, a 6-year-old girl who was either standing on or holding onto the swim platform at the rear of a boat lost consciousness and fell into the water. She was described by a witness as "getting sick as she was riding on the platform". She lowered her head into the water, released the platform, and sank. Her body was found in 12 feet of water. Her COHb concentration was 61%. (Source: A series of articles from area newspapers) **Propulsion engine exhaust**

II. Outdoor CO Poisonings on Cabin Cruisers and Ski Boats – U.S. Waters

Dog River, Alabama

In September 1997, a 10-year-old passenger riding on the swim platform of a 19' 1989 Correct Craft ski boat was fatally poisoned within two minutes of exposure to engine exhaust while the boat was operating at idle speed. The boat was powered by a 1995/1996 240-horsepower inboard engine. Four juveniles were riding on or holding onto the swim platform in an activity that was described to investigators as "common practice" by the owner of the boat. When the boat was at idle speed, the four passengers climbed out onto the swim platform. They were positioned in various places on the platform: sitting on the platform; holding onto the platform with arms extended and being towed behind the boat; chest up on the swim platform with legs dangling behind the boat, etc. About two minutes after they got on the platform and the boat began to move at idle speed, the victim let go of or fell from the platform, separated from the boat, drifted astern of the boat for approximately 50 feet, and sank beneath the surface in 18' of water. None of the passengers were wearing a personal floatation device. His body was recovered six hours later. His COHb on autopsy was 50%. Cause of death listed on the death certificate was carbon monoxide toxicity and drowning. (Source: Alabama Marine Police Marine Accident Investigation Report, Alabama Department of Forensic Sciences Report of Autopsy) **Propulsion engine exhaust**

Unspecified water body, Utah

- In 1996, a passenger sat on the swim platform while the engine was running and was poisoned. (Source: US Coast Guard Database) **Propulsion engine exhaust**

- In 1997, a water skier was poisoned as she was preparing to ski. (Source: US Coast Guard Database) **Propulsion engine exhaust**

Candlewood Lake, Connecticut

In August 2001, a boy who was being pulled behind a ski boat while holding onto both the metal handle attached to the transom and the slotted teak wood swim platform. According to the investigator reporting the incident, the boy began to have problems with his bathing suit after being towed for an estimated 10-15 minutes. He released the platform, floated briefly, lost consciousness and sank (he was not wearing a personal floatation device). His body was recovered several hours later. His COHb measured during the autopsy was 56%. (Source: Law enforcement officer investigating the incident) **Propulsion engine exhaust**

St. John's River, Florida

In May 2000 an 8-year-old boy died from CO poisoning while he was on or near the swim platform of a 1997 pleasure motor boat. The boat was anchored in the river, and the onboard generator was operating, with exhaust discharging to the rear of the boat in close proximity to the platform where the boy was positioned. The boy disappeared from the platform. His body was later found in the water. The autopsy revealed that the boy's carbon monoxide blood concentration was 34.8%. (Source: Law firm representing the family of the boy.) **Rear-directed generator exhaust terminus**

Lake Mead, Nevada

- A child lying on a personal water craft with her face next to the exhaust port was poisoned as the craft moved across the water. She lost consciousness and was unable to respond to EMS personnel. She recovered after treatment with oxygen, and was transported to a local hospital. (Source: Review of NPS EMS records) **Propulsion engine exhaust**

Unspecified water body, New York State

■ A 16-year-old girl bathing off the stern of a recreation open bow motor boat (1981 Crestliner 17' pleasure craft) died from CO poisoning. The boat was in the center of a freshwater lake. The boat engine was operating because the girl's swimming partner had asked other boat occupants to activate it to warm the water where they were swimming behind the boat. After swimming for approximately 10 minutes her partner felt tired and cold and got back into the boat. As he looked back at the girl still in the water, he noticed that she put her head in the water, and then disappeared. He thought she was taking an underwater dive, but became alarmed when she didn't resurface. Her body was found five days later, 50-feet deep in the water. The autopsy revealed a carbon monoxide blood concentration of 62%. Testing of the boat conducted after the death revealed that CO was present in concentrations of 100 ppm in the air several inches above the water level at the stern when the engine idled for 8 minutes. The largest accumulation of CO was at the stern just above water surface as well as at the transom. (Source: Peer-reviewed publication – Jumbelic MI [1997]. Open air carbon monoxide poisoning.] **Propulsion engine exhaust**

Unspecified water body, Washington

■In 1995, an occupant of an open motorboat powered by an outboard engine was poisoned while in the water. The victim tried to untangle a ski rope from the engine propeller while the engine was operating. The person climbed back into the vessel, but said he was dizzy. He then dove back into the water, became unresponsive, and floated towards the front of the vessel where he sank. His body had not been recovered when the report was submitted. (Source: US Coast Guard Database) **Propulsion engine exhaust**

Unspecified lake near Phoenix, Arizona

■ In 1997, on a lake near Phoenix, a 13 year old girl was found dead in the stern seat of a ski boat that had been operating around the lake for a couple of hours. She moved to a seat in the back of the boat while the family was headed back to the dock, and about 15-20 minutes later she was discovered to be dead. Examination of her blood postmortem revealed high CO levels. The sheriff's office recorded that they examined the boat and motor, but did not identify any problems. (Source: Arizona Health Department) **Propulsion engine exhaust**

III. Indoor CO Poisonings on Houseboats – U.S. Waters

■ *3 CO-Related Fatalities in this Category* ‣ *104 Non-fatal CO Poisonings in this Category*

Lake Powell, Utah and Arizona

‣ Since 1990, 36 people have been overcome by CO poisoning while occupying the living quarters of houseboats on Lake Powell. All of these poisonings were associated with exposure to generator exhaust, and all 36 people survived. (Source: Review of NPS EMS Records, Glen Canyon National Recreation Area)

Cumberland, Kentucky

‣ In June 2000, 15 people, ages ranging from 16 to 47, were overcome by CO on two rented houseboats. One of the houseboats was a 3-month-old 77-foot Stardust. The other boat was manufactured by Horizon. The boats were tied together and anchored in a cove. Both boats had gasoline-fueled generators; the generator on the Stardust boat was marina installed with side-directed exhaust terminus. The exhaust of one of the generators seeped into the adjacent boat through an open bathroom window. CO was circulated through the full interior of the boat by the central air-conditioning system. Boat occupants who awoke at about 5 a.m. had headaches and were nauseous. Realizing they had a problem, the group radioed the marina and ambulances met the boats at the shore. The Kentucky Water Patrol Officer that responded to the emergency witnessed that two occupants were unconscious when he arrived, and others were drifting in and out of consciousness. All 15 people were treated at the emergency department of a nearby hospital; three were admitted as hospital inpatients for further treatment. There were six carbon monoxide detectors on this boat, but none were properly connected when the boat was inspected after the poisoning incident. Boat occupants initially denied disconnecting the detectors, but later took responsibility for that act and ignoring warnings. (Source: News articles from an unspecified newspaper, further details from a Stardust Cruisers, Inc. representative) **Side-directed generator exhaust terminus**

Dale Hollow Lake, Kentucky

‣ In April 2000, 11 people were poisoned inside the houseboat they were occupying. One person lost consciousness, and 9 children experienced vomiting and extreme headaches. They ran the generator during the nights while they slept. They were told at the hospital that this was the second time this year that his had happened at this lake. (Source: Lake-Times News, May 1, 2000; personal communication – e-mails from victims) **Unspecified generator exhaust terminus location**

The Delta, Stockton California

‣ In June 1999, on a houseboat anchored in Dredge Cut, 9 boat passengers, a medical technician, and a deputy people were poisoned by carbon monoxide from a propane-powered generator. The emergency medical technician and a fellow deputy became poisoned as they worked to diagnose the problem and evacuate boat occupants. No other details were available from the newspaper article covering the incident. (Source: San Francisco Examiner, Saturday Jun 19, 1999) **Unspecified generator exhaust terminus location**

Laurel Lake, Kentucky

‣ Six adults and 11 children were roused in the early morning only when a passenger heard her 20-month-old son vomiting. As the mother tried to get to her son, she could hardly move. Gradually, she arose, wakened the remaining passengers who reported feeling drowsy, sick, and wracked by headaches. All passengers were diagnosed as having CO poisoning, with CO blood levels ranging from 3 to 17 percent. One passenger was hospitalized, and the others were treated with oxygen and released. The victims were on a rented 72-foot houseboat that had a gasoline-powered generator that was operating at the time of the poisonings, and had been operating through out the night. There were no CO detectors on the boat. (Source: Lexington Herald-Leader, Stephen Trimble. Found in an internet search, no date listed on the article.) **Unspecified generator exhaust terminus location**

Lake Meredith National Recreation Area (US NPS), Texas

■ ■ ■ In March 1984, three people died as they slept on a boat docked in the marina. A faulty exhaust manifold on a generator was blamed as the three died of carbon monoxide poisoning. (Source: Amarillo Globe-News, September 4, 1999) **Unspecified generator exhaust terminus location**

III. Indoor CO Poisonings on Houseboats – U.S. Waters

Lake Mead (US NPS), Nevada

- In November 1996, a man working on a houseboat "in a confined space for 7 hours" and exposed to "noxious fumes" experienced headache, nausea, vomiting, dizziness, light-headedness, and difficulty walking was assessed as having CO poisoning and transported by air to a local hospital. (Source: Review of NPS EMS records) **Unspecified generator exhaust terminus**

- In October 1997, a woman was asleep in the rear cabin of a houseboat when the CO alarm sounded , awaking her and others on the boat. The woman lapsed into unconsciousness and also suffered from nausea. She was transferred to a hospital for treatment. Records indicated that two houseboats were tied together, and that both boats were operating their generator. (Source: Review of NPS EMS records) **Unspecified generator exhaust terminus location**

- In July 2000, four occupants of a houseboat were poisoned while sleeping in the rear cabin. The on-board generator was operating at the time of the poisoning. An inspection of the boat indicated that plumbing holes in the floor of the adjacent bathroom allowed CO to enter the sleeping area. In addition, it was also noted that the exhaust for the generator was close to the cabin's rear area. Inspectors suggested that the exhaust be moved closer to the rear of the boat. (Source: Review of NPS EMS records) **Side-directed generator exhaust terminus**

Table Rock Lake, Missouri

- In July 2000, 8 people were poisoned on a houseboat rented from Tri-Lakes Houseboat Rentals. Records related to this incident indicated that the County Fire Department measured "high levels of CO on the stern deck of the boat and in the engine compartment while the generator was running." They also checked inside the passenger area of the boat, and found "levels were higher than normal when the back door of the boat was open." The wiring to the CO detector on board the houseboat had been cut at some point, and the CO detector was not functioning at the time of this incident. The CO detectors were not routinely checked on the boats. It is not clear from this report where the poisoned occupants were when the onset of symptoms occurred. It is assumed that some of the victims were on the stern deck because the report refers to measurements in that area. However, the number of people poisoned indicates that the exposure may have occurred inside the boat. (Source: Missouri Department of Public Safety, Missouri State Water Patrol Accident Investigation Report) **Unspecified generator exhaust terminus**

IV. Indoor CO Poisonings on Cabin Cruisers or Boat with Canopies – U.S. Waters

■ *12 CO-Related Fatalities in this Category* ‣ *62 Non-Fatal CO Poisonings in this Category*

Lake Powell, Arizona and Utah

■ ‣ ‣ ‣ Since 1990, 1 person has died of CO poisoning while riding inside an enclosed area of a pleasurecraft (not a houseboat). On May 5th, 1995 two occupants of a disabled vessel called for assistance. They joined the two occupants of the assisting vessel, the boat described above, while the disabled vessel was in tow. The tow was initiated at approximately 7:20 p.m. with one person at the helm, and the three other passengers seated in the boat's canopied cabin. Within an estimated five minutes, all passengers were overcome by carbon monoxide from the engine exhaust. The vessel continued to run until all the fuel in the 60-gallon tank was consumed. The boat was found on May 6th at 9:22 a. m. in a resting position on shore. The person at the helm had no pulse and was cold to the touch. His COHb on autopsy was 55%. The other passengers, who had begun to regain consciousness at approximately 9:00, were disoriented. They were transported to the hospital for treatment. (Source: Review of NSP EMS Records, Glen Canyon National Recreation Area)

‣ Since 1990, 20 people have been poisoned while in the cabin or within a canopy of a pleasurecraft (other than houseboat) on Lake Powell. Six of the 20 people were poisoned by generator exhaust while inside a cabin cruiser boat during a single incident. The remaining 14 people were poisoned by propulsion engine exhaust. Nine of the 20 people lost consciousness as a result of their exposure. (Source: Review of NSP EMS Records, Glen Canyon National Recreation Area)

Lake of the Ozarks, Missouri

■ ■ ■ ■ In June 1999, four people died as a result of CO exposure inside a 40' Silverton Cabin Cruiser that was tied to a dock. A Water Patrol officer found the boat docked at a restaurant, where it was reported to have been docked for two days. Lights inside the houseboat were operating and the generator was running. A 40-year-old man and two friends were found dead inside the boat. The man's wife was observed to be breathing when emergency responders arrived, but died shortly thereafter. The cause of death was carbon monoxide poisoning resulting from a rusted generator exhaust pipe that allowed CO to leak into the cabin of the boat. The local fire department measured 272 parts per million of CO inside the cabin door of the cruiser after the victims had been removed from the boat cabin. (Source: Several, including news clips forwarded by Scott Thomsen, AP; News coverage from the Jefferson City News Tribute, Wednesday June 2, 1999; pieces from the internet) . (Also: Missouri Department of Public Safety, Missouri State Water Patrol Incident Report Number F99-3410) **Unspecified generator exhaust terminus location**

‣ In September 1998, six people were overcome by CO while riding in the cabin of a 1986 36' Carver Cabin Cruiser powered by an inboard/outboard propulsion engine. The boat was traveling at approximately 20 miles per hour with the door to the cabin open when one member of the party informed the pilot that someone was ill. Approximately 30 seconds later, people in the cabin began to lose consciousness. The six passengers overcome by CO exposure were transported by ambulance to a nearby hospital for treatment. (Source: Missouri Department of Public Safety, Missouri State Water Patrol Incident Report Number H98-3710) **Propulsion engine exhaust**

Laurel Lake, Kentucky

‣ In August 1998, six people were overcome by carbon monoxide and transported by ambulance to Lake Ozark General Hospital for treatment. The operator of the boat advised investigators that the 36' Carver Cabin Cruiser boat was headed for Bridal Cave where two of the passengers were to be married. The door to the cabin was open while the boat was en route. This allowed CO to enter the cabin area. (Source: Missouri Department of Public Safety, Missouri State Water Patrol Incident Report Number H98-3710) **Unspecified generator exhaust terminus location**

Lake Mead (US NPS), Nevada

■ ‣ In May 1993, two people were poisoned (one died and one survived) while they slept in the cabin of an anchored (at shore) 25' 1981 Searay Cabin Cruiser. The source of CO was an on-board gasoline-powered generator. No loose fittings or leaks were found. (Source: Review of NPS EMS records) **– Rear-directed generator exhaust terminus**

Kentucky Lake, Tennessee

■ ■ In November 1999, a Tennessee Wildlife Officer, a county sheriff, and an investigator entered an "abandoned" 1966 36' Chris Craft cabin cruiser near the mouth of Standing Rock Creek on this lake. Two deceased occupants were located in the living quarters of the boat. An autopsy was ordered because CO poisoning was suspected as the cause of death. (No results are referred to in the available record.) An inspection of the boat indicated that a coupling on the hose leading from the generator exhaust port to the stern bulkhead was damaged, with an open area approximately 8-10 inches long. An onboard CO detector was found near the entry into the living quarters. The test button did not work. The wiring was traced to the port engine switch. When this switch was turned to the "on" position, the detector received powere and the test button worked. A review of the travel log on the vessel indicated that the temperature on the night of the last entry was in the low 30 degrees F to high 20 degrees. The vessel was found anchored at both ends, with all hatches and covers closed tight. (Source: Tennessee Boating Accident Investigation Record) **Unspecified generator exhaust terminus location**

Lake Norman, North Carolina

‣ Six boaters became ill from CO that leaked into the cabin of a 36-foot boat docked at a restaurant. The boat's onboard generator was operating to power the boat air conditioner. Four adults and two girls, aged 8 and 9, were treated for CO poisonings at Carolinas Medical Center and Presbytarian Hospital. (Source: News clips forwarded by AP) **– Unspecified generator exhaust terminus location**

Unspecified water body, Florida

■ In June 1995, a man went to check out his boat that was docked at its bulkhead. He activated the boat's air conditioner, and left up the canvas and plastic covering that enclosed the top deck. A few hours later, he was found dead. The boat's engines, generator, and air conditioning system were still operating and the boat's CO alarm was sounding. Exhaust from the boat's engines coming in through the rear entry flap of the boat's deck covering had killed him. Testing of the CO alarm indicated that the alarm was miscalibrated and did not go off until almost an hour after it was supposed to. By the time the alarm sounded, the man could no longer help himself. One result of lawsuits related to this case was the discovery that testing conducted by the manufacturer of the CO alarm showed repeated malfunctions of the alarms. Changes in the manufacturing process had allowed contamination of sensitive components of the alarm. According to the manufacturer, the alarm sensor mimics the body's carboxyhemoglobin level over a period of time. There had been a longstanding problem with other gases and fumes contaminating the sensor during the manufacturing process. This would cause the sensor to "drift", which in turn results in miscalibration of the sensor, and faulty alarming. The following information is included in the court's decision:

"The United States Coast Guard and a well-known boating industry organization, the American Boat and Yacht Council (ABYC) went to great lengths to try and educate the boating industry to the potential for carbon monoxide poisoning. For several years prior to the manufacture of this boat, the ABYC developed a recommended standard that went into effect shortly after the decedent's boat was manufactured. However, this recommended standard was widely circulated within the boating industry well prior to the construction of decedent's boat. Further, the boat manufacturer did absolutely no scientific testing to determine if and how carbon monoxide would enter into its boats after they had been constructed. The closest testing that [the boat manufacturer] did consisted of a "sniff" test performed by its primary boat designer and its boat tester, both of whom were very "sensitive" to carbon monoxide." Other problems were that the CO alarm was installed in an area of the boat cabin contrary to instructions in the alarm manual, was wired directly to the boat batteries which caused the batteries to fail. Further, there were no instructions or warnings given to the decedent about operating conditions in which he would be exposed to hazardous levels of CO. The settlement for this case was $3,000,000 for the wife of the victim. (Source: Pajcic and Pajcic "Profiles and Precedents" biannual report of settlements for the last six months of 1997; and Florida Jury Verdict Reporter, a publication of Florida Legal Periodicals, Inc., Volume XVIII, No. 10, Oct 1997) **Unspecified generator exhaust terminus location**

IV. Indoor CO Poisonings on Cabin Cruisers or Boats with Canopies – U.S. Waters

Mississippi River, Tennessee

In August 1990, two people died and another was seriously injured as a result of CO exposure on their 32' Trojan cabin cruiser. Witnesses heard someone calling for help from aboard the boats. When a witness arrived at the boat, the injured person was found trying to revive one of the victims by giving her mouth-to-mouth resuscitation. The injured person was removed from the vessel, and the other two people on board the boat were found to be dead. A small dog on board was alive, but unable to walk. The injured person was flown to a nearby hospital and treated for CO poisoning. The county coroner determined that the cause of death for both of the other victims was CO poisoning. Inspection of the exhaust system of the boat's onboard generator indicated that there was a leak in the line from the generator to the rear of the boat that could have resulted in exhaust "backing up" into the cabin area of the boat. The survivor of the incident was interviewed, and revealed that the generator had been operating for over 8 hours when the boat occupants began watching a movie. The next thing the survivor remembered was waking up on the floor after daylight, vomiting. He left the boat to wash himself. When he got back on the boat, he tried unsuccessfully to wake the other occupants. (Source: Tennessee Boating Accident Investigation Record) **Rear-directed generator exhaust terminus**

Unspecified water body, California

In 1998, seven people were out cruising in a cabin cruiser boat powered by an inboard engine. Three people were above deck and four were below deck. There appeared to have been a ventilation system failure that caused CO to enter the cabin area, sickening all four people below deck. The two most seriously affected were a 7-year-old female and a 4-year-old male. All received medical attention and recovered. (Source: US Coast Guard Database)

Unspecified water body, Wisconsin

In 1998, four people were poisoned while riding in a cabin cruiser boat powered by an inboard engine. The boat was traveling southbound on a river and due to a tailwind, coverings on the boat, and how the boat was operated, carbon monoxide built up in the lower berth of the boat where the people were poisoned. (Source: US Coast Guard Database)

Unspecified water body, Nevada

In 1997, 10 passengers on a cabin cruiser boat powered by an inboard engine were treated for CO poisoning at a local hospital. The weather was adverse with choppy water and moderate winds. Thunderstorms were present with occasional rain. The canvas side curtains were lowered and the vessel proceeded slowly. The stern area of the vessel was not covered by canvas. The side curtain canvas configuration allowed CO from the exhaust ports to be drawn over the transom and back into the boat. This tunnel effect or back drafting exposed the people on board to dangerous levels of CO. Passengers were in various degrees of nausea, unconsciousness, and convulsions. Medics were summoned and passengers were treated with 100% oxygen at the site. They were transported to a local hospital. The Fire Department detected elevated CO concentrations below deck, especially in closed cabinets and spaces. (Source: US Coast Guard Database)

Unspecified water body, Washington

In 1996, two people were poisoned while riding in a cabin cruiser boat powered by an inboard engine. After reporting engine trouble, one of the people crawled into the engine cavity to check on the problem. He was overcome and passed out from exposure to the exhaust. The second person was also overcome. Occupants of another boat came along side and saw the victims. He radioed for assistance. The victims were flown to a local hospital where they were treated for CO poisoning. (Source: US Coast Guard Database)

Unspecified water body, Utah

In 1995, three boys were poisoned inside a cabin cruiser boat powered by an inboard engine. They were in the cabin of the boat with the engine operating. One of the boys died. (Source: US Coast Guard Database)

4 Non-Fatal CO Poisonings in this Category

Lake Powell, Utah and Arizona

Since 1990, there have been 4 non-fatal poisonings on this lake that occurred on a boat, but the type of boat was not specified in the medical record. (Source: Review of NPS EMS Records, Glen Canyon National Recreation Area)

Totals for all Categories

Category	CO-Related Deaths poisonings	Non-Fatal Poisonings
I	19	45
II	12	19
III	3	104
IV	12	62
V	0	4
Total – 279	45	234